Präzisionsmessungen der kosmischen Höhenstrahlung im Weltraum
Das AMS Experiment auf der Internationalen Raumstation ISS

für die AMS-Kollaboration
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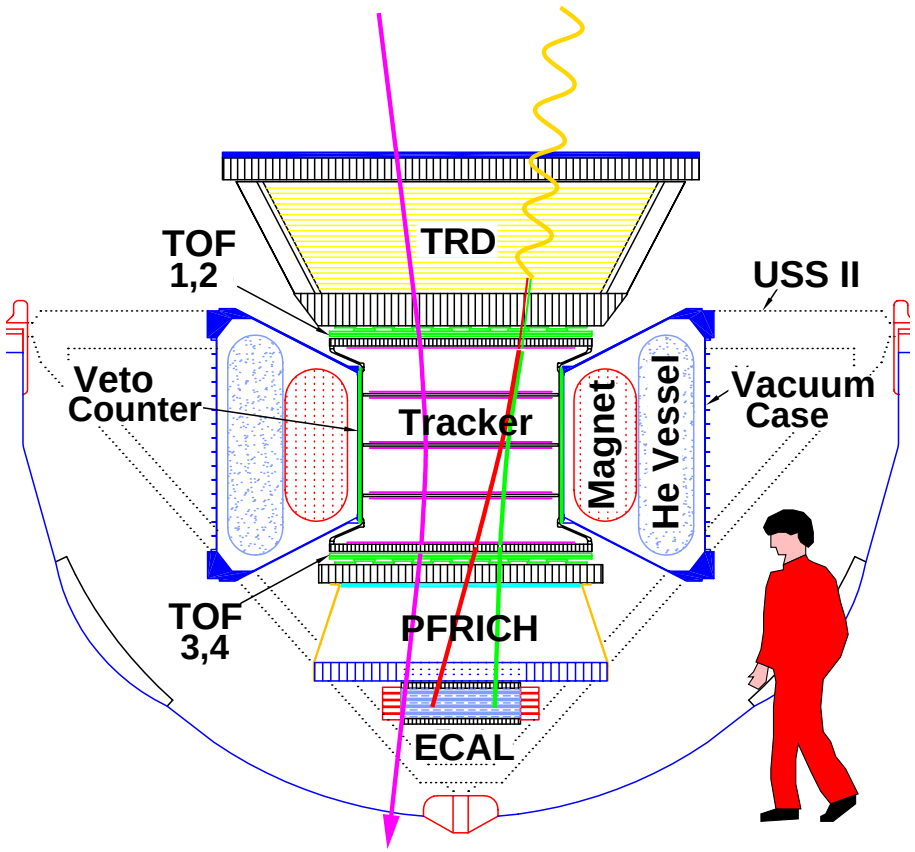
I. Phys. Institut RWTH Aachen

Leipzig, 18. März 2002

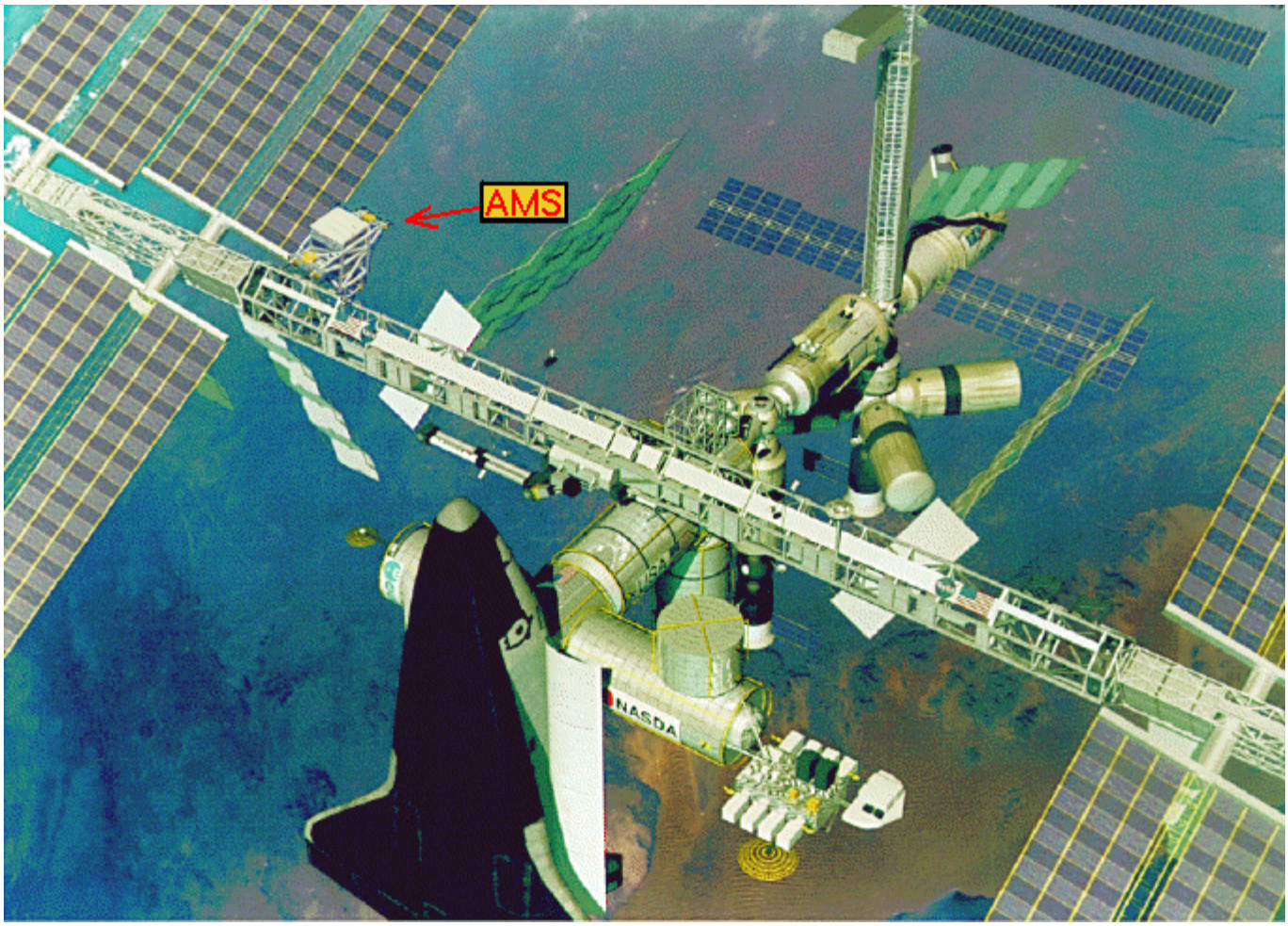
The AMS Detector

- AMS02 on ISS
- Cosmic Particle Spectroscopy
- AMS01 Results
- AMS02
- Conclusion



Height: 3.50 m
Width: 2.30 m
Weight: 7 t

ISS - an experimental platform



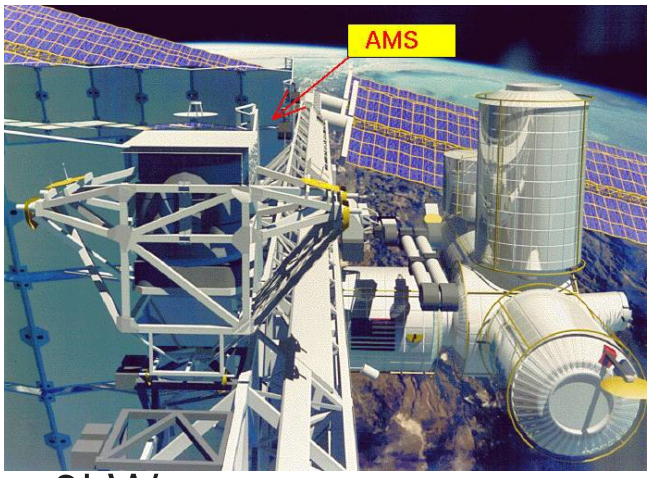
AMS02 on ISS

- Mean altitude 400 km
- in orbit for 3 years
- acceptance 0.5 m^2sr

$\Longrightarrow$ Cosmic Particle Spectroscopy

Experiments in Space
New environment for HEP experiments

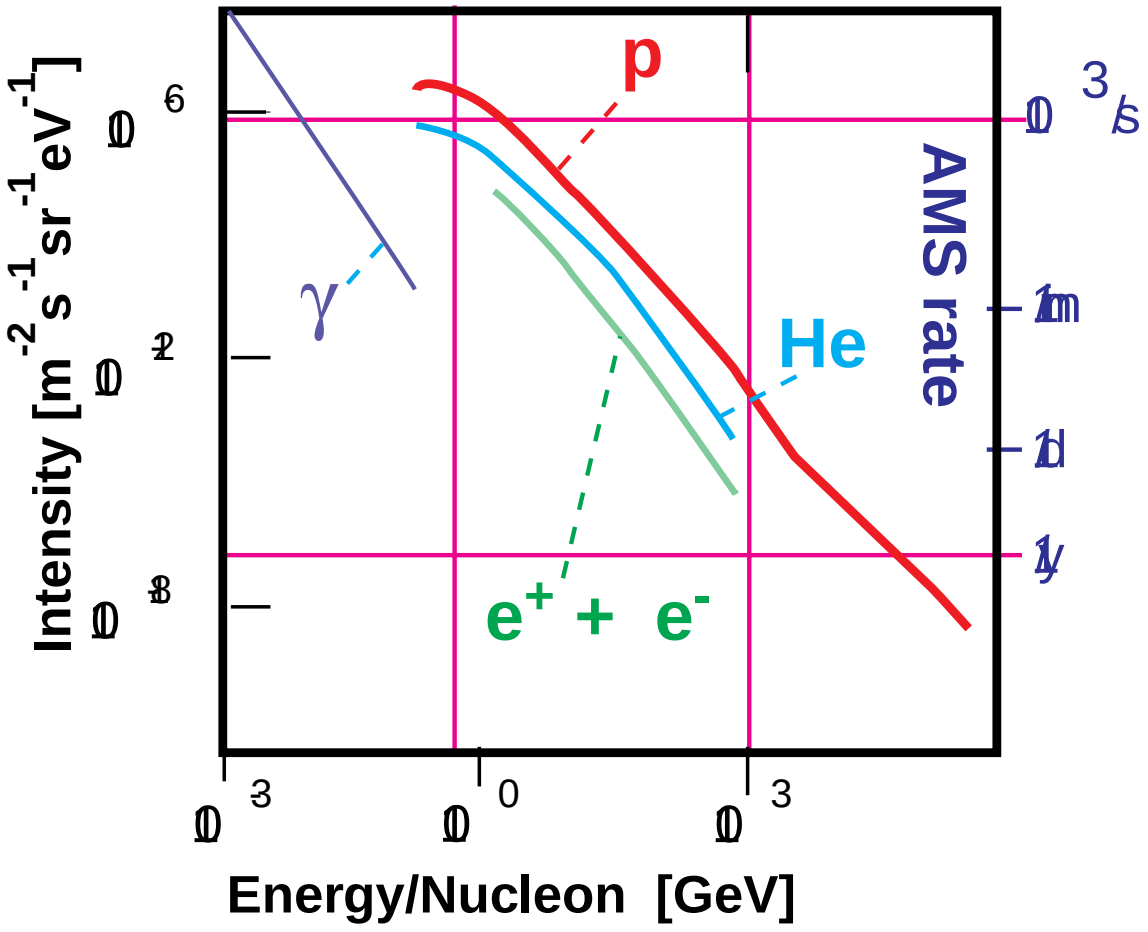
- Acceleration during start and landing; Design Goal up to 9g



- Operation in vacuum
- Temperature variations
  -150 - $+30$ °C
- Deposition limits on ISS
  $< 10^{-14}$ g/s/cm^2
- Weight limited to 14000 lbs
- Power consumption limited to 2kW
- Single Powersupply at 120 V
- Datarate 1 Mbyte/s via 1 datalink

$\Longrightarrow$ Cosmic Particle Spectroscopy

Cosmic Particle Spectroscopy



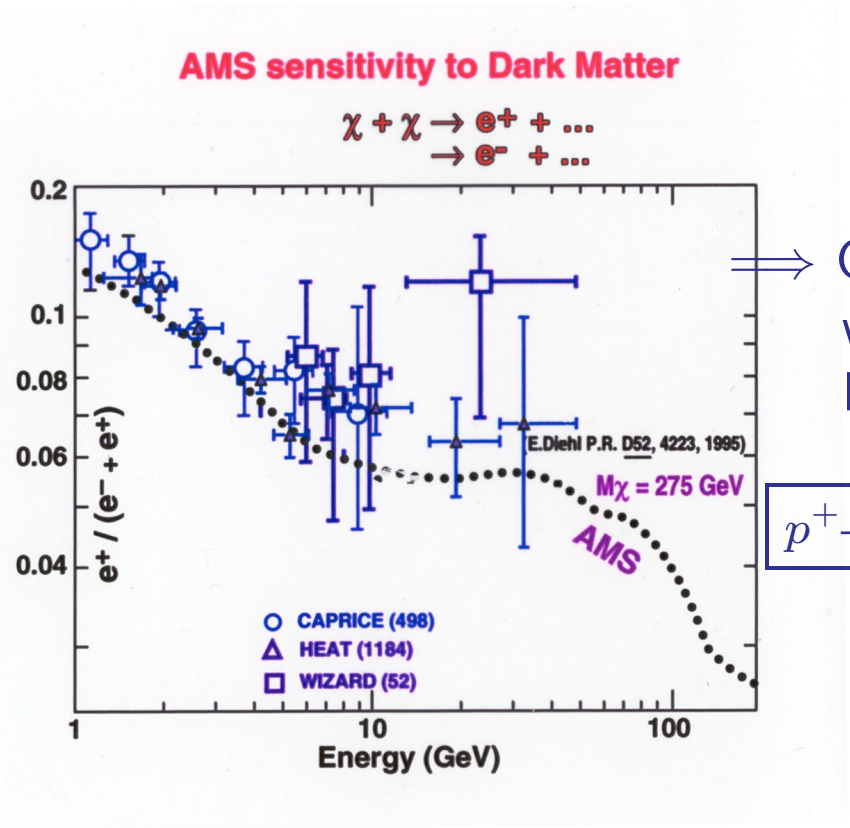
flux ratio in orbit:
$p^+/e^+ \approx 10^4$

p^+-Contamination:
$\leq 10^{-2}$

$\Rightarrow p^+$-rejection $> 10^6$

AMS Physics Goals

- Dark Matter Search $\Rightarrow$ e^+-Spectroscopy



$\Longrightarrow$ Cosmic-ray spectroscopy with highest-precision in Particle identification

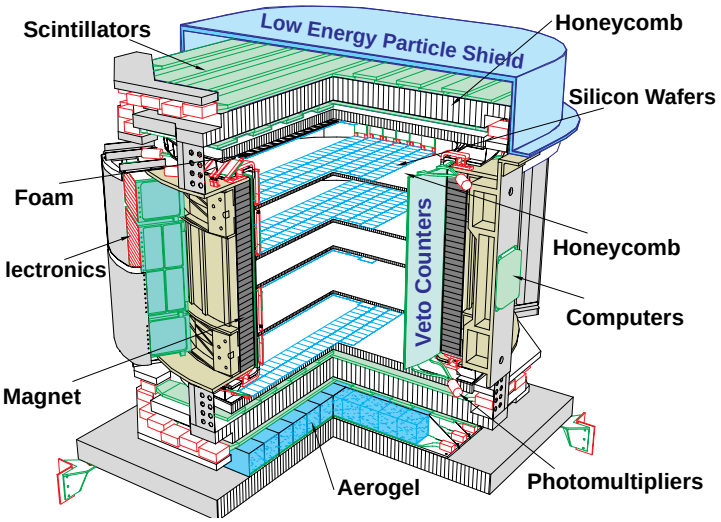
p^+-rejection $> 10^6$ to 300 GeV

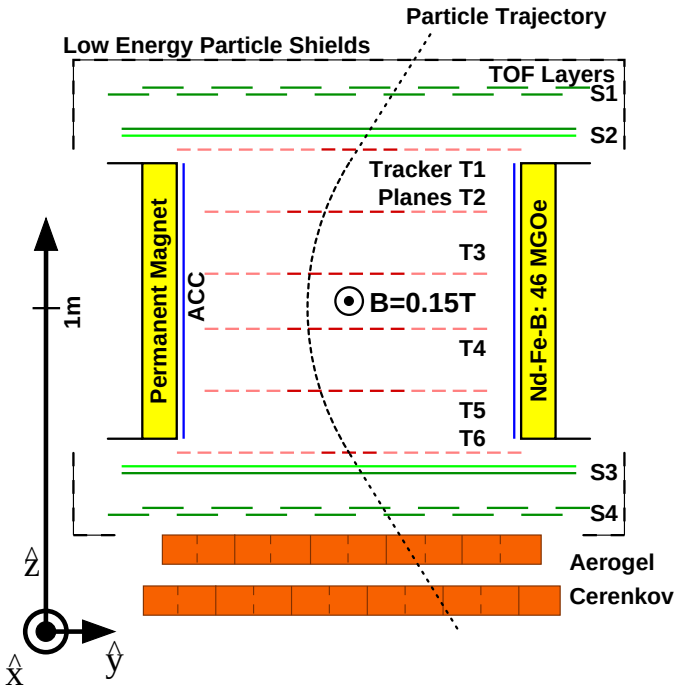
- Matter-Antimatter Symmetry $\Leftrightarrow$ Antimatter Search

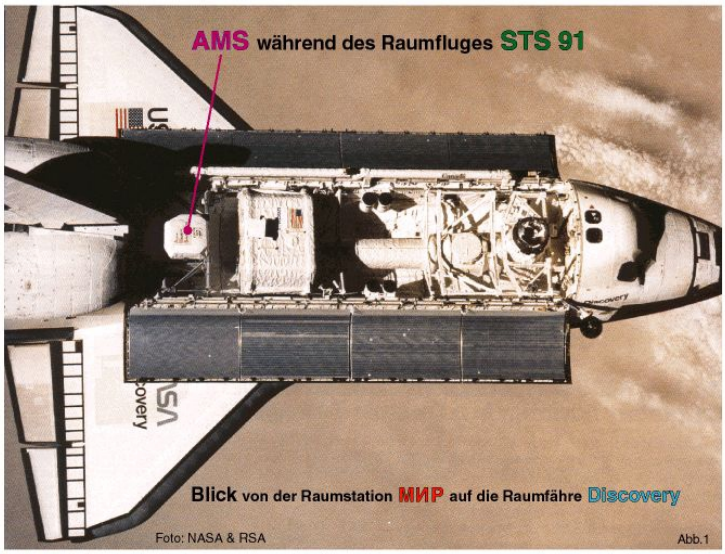
$\overline{He}$: cosmic antimatter
$\overline{C}$: antimatter stars

$\Delta p/p < 30\%$ to 1000 GeV

AMS01 STS-91 Precursor Flight

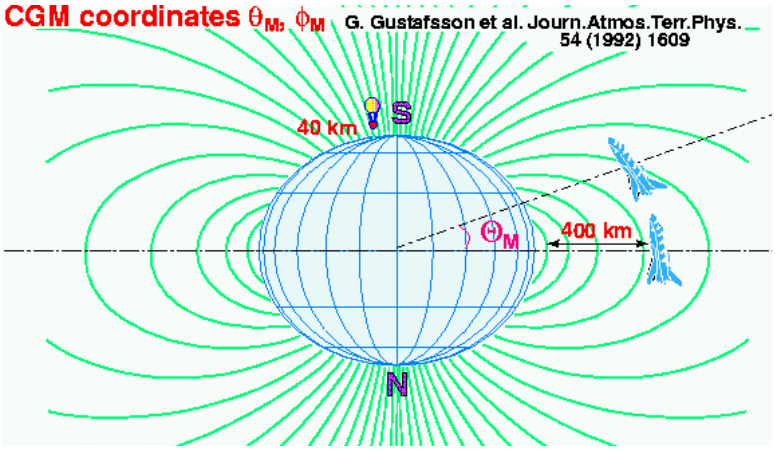




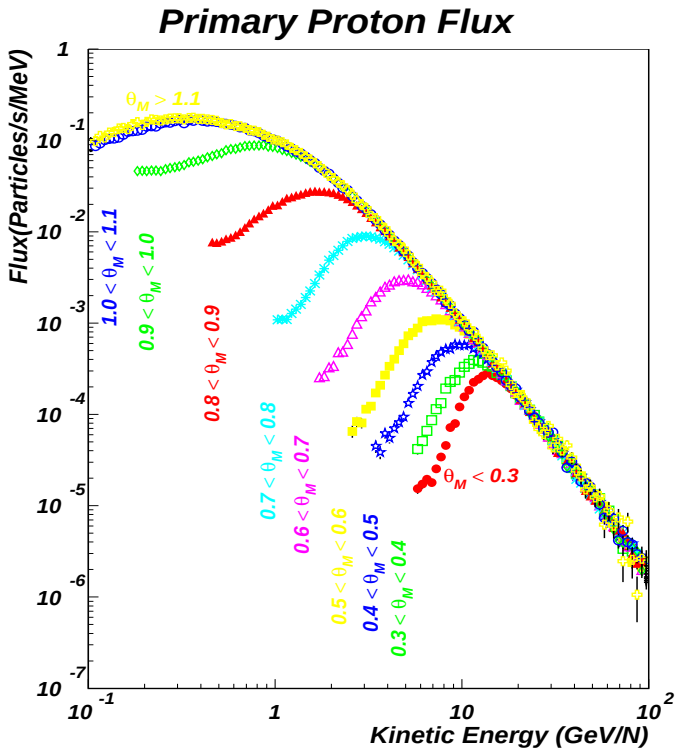


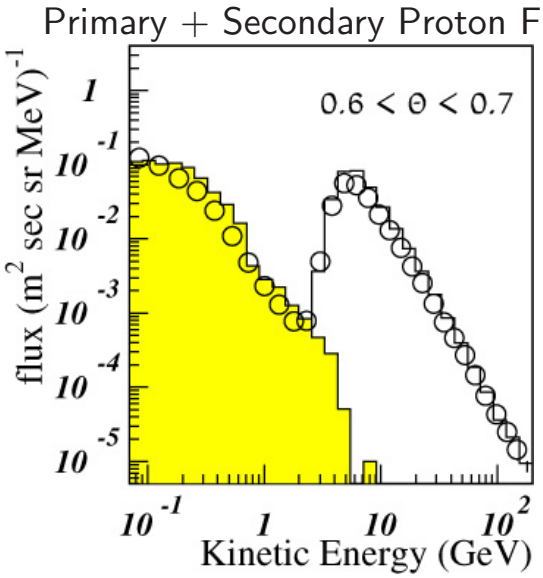
- STS-91 2-11 June 1998
  Shuttle Discovery
- Mean altitude 370 km
- 90 min orbit inclined at 51.7°
- Trigger-rate 100-700 Hz
- Recorded 10^8 events in 100 h

AMS01 Results



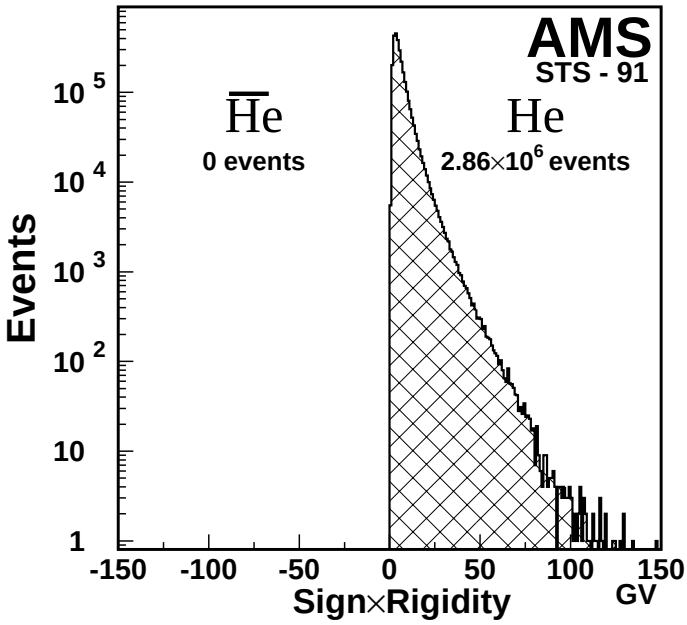
Maximum *rigidity (p/Z)* depends on *magnetic* latitude

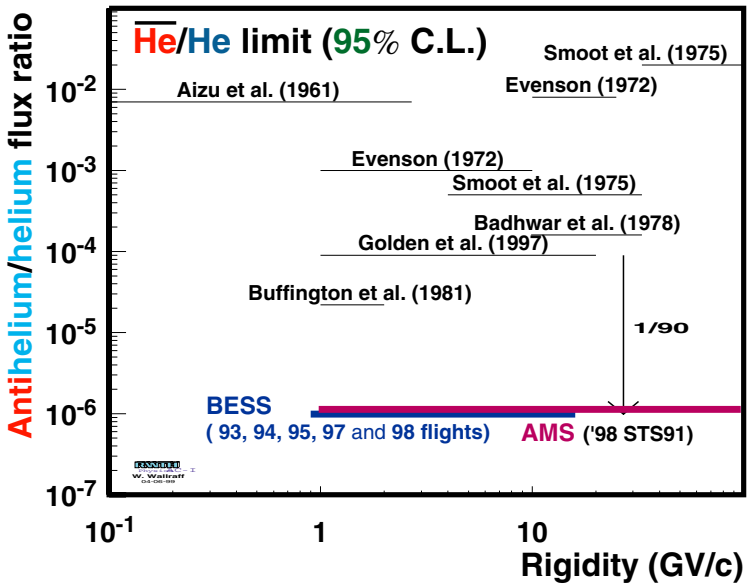




Full Geant simulation of the earth magnetic field lead to a detailed understanding of the measured spectra

AMS01 Results





Assume $\overline{He}$ and He have the same spectrum then

- AMS-01 98: $\overline{He}/He < 1.1 \cdot 10^{-6}; R < 100\ GV$
- BESS 93-98: $\overline{He}/He < 1.0 \cdot 10^{-6}; R < 16\ GV$

Search for Antihelium in Cosmic Rays
Phys. Lett. B461 (1999) 387-396

Protons in Near Earth Orbit
Phys. Lett. B472 (2000) 215-226

Leptons in Near Earth Orbit
Phys. Lett. B484 (2000) 10-22

Cosmic Protons
Phys. Lett. B490 (2000) 27-35

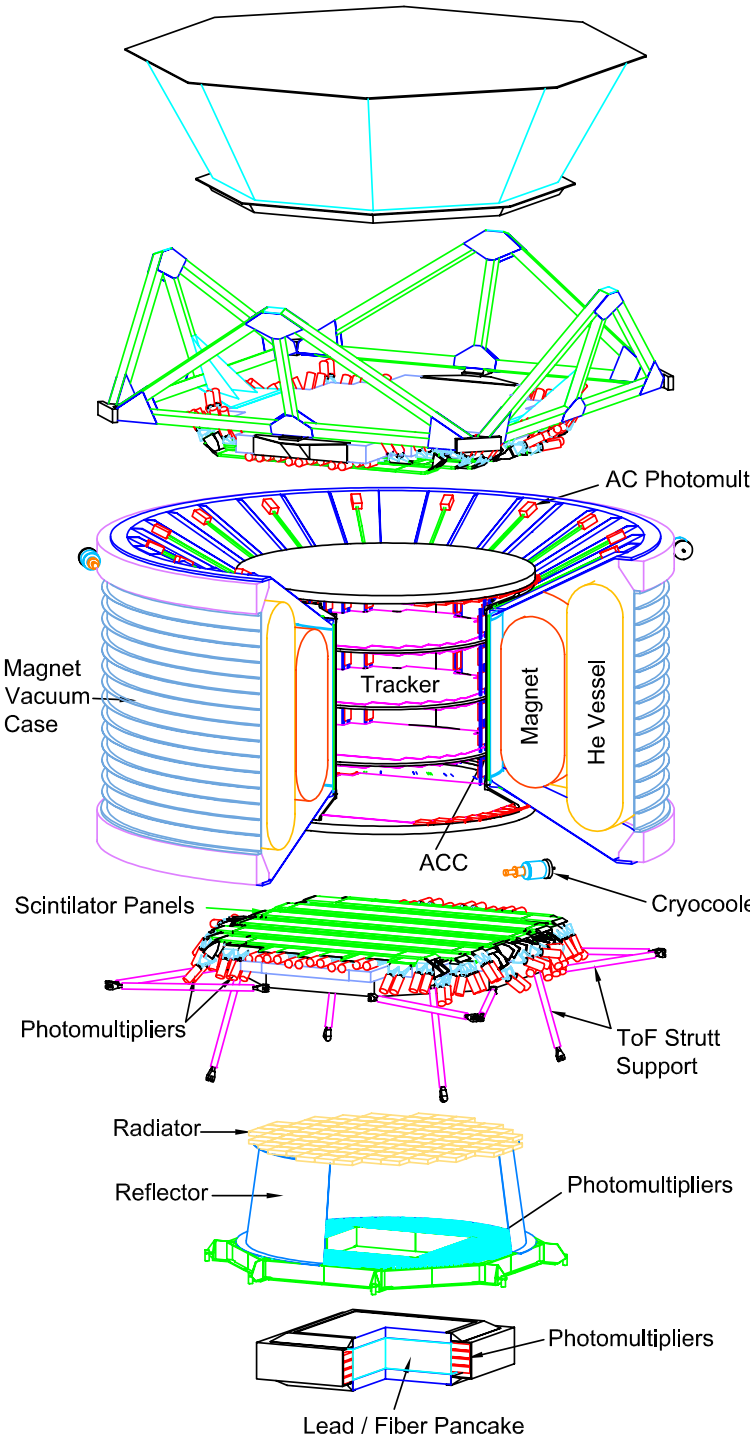
Helium in Near Earth Orbit
Phys. Lett. B494 (2000) 193-202

50 AMS01 related papers submitted to ICRC 2001

AMS02 – A Particle Spectrometer for ISS

How to suppress proton background to 10^{-6} and perform high statistic tracking up to 1 TV?

Large acceptance 0.5 m^2sr in orbit for 3 years



TRD Particle ID & 3D tracking
20 layers fleece + Xe/CO2
5248 channels 6mm straw-tubes

p^+-rejection $> 10^2$ (10 - 300 GeV)

TOF 1,2 Trigger $\sigma_t \approx 125$ps

Anticoincidence (Veto) counter

Silicon strip tracker
with internal laser alignment
6 m^2 in 3 double + 2 single xy layers
1σ charge separation up to 1TV

Superconducting Magnet (ETH)
B = 0.9T V = 0.6m^3

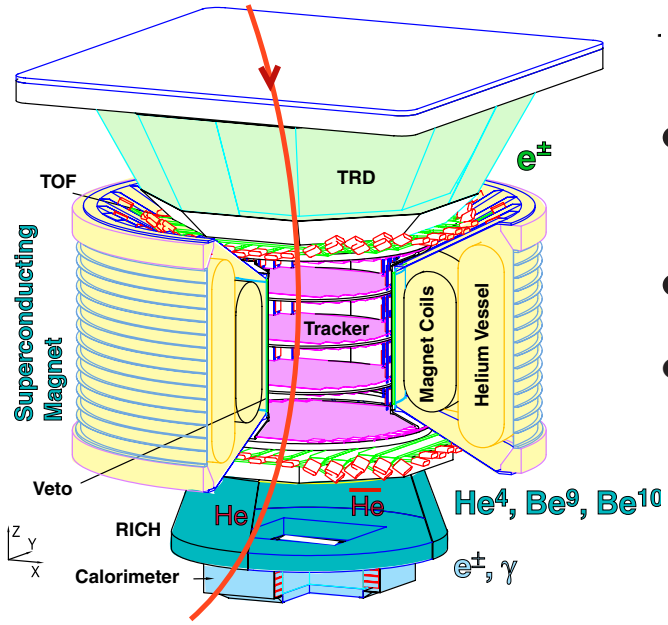
TOF 3,4 1.3m distance to TOF 1,2
$p^+/e^+ > 3\sigma$ below 2 GeV

PFRICH AGL(+NaF) Radiator
for A$\leq$27 and Z$\leq$28
separation $> 3\sigma$ from 1-12 GeV

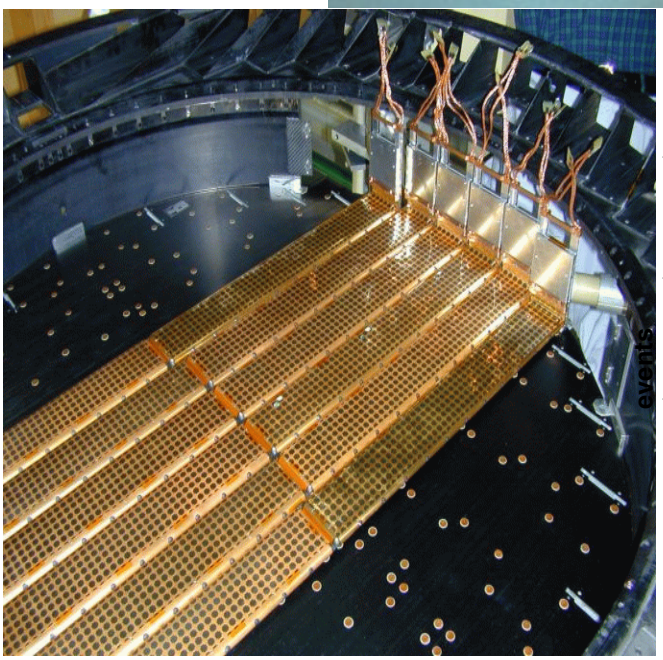
ECAL 3D sampling lead/scint.-fibre
with p-E matching and shower-shape

p^+-rejection $> 10^4$ (10 - 300 GeV)

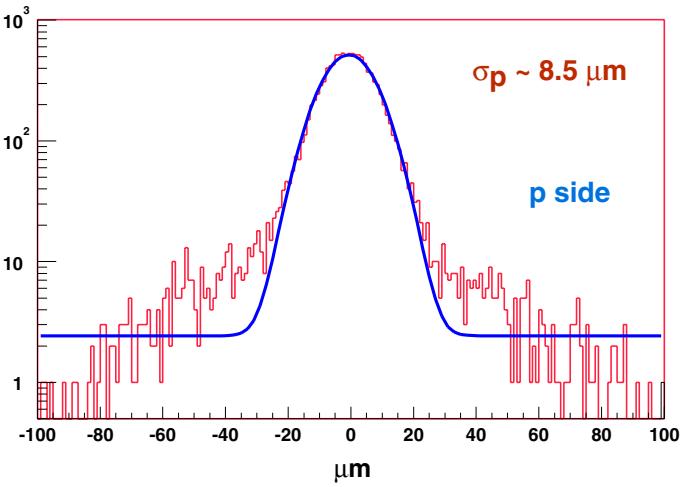
AMS-02 Silicon Tracker



- 8 layers, pitch 110 μm, $\Delta = 10\mu$m
- sagitta @ 30 GeV 1 mm
- largest particle physics Si-tracker before the turn-on off LHC

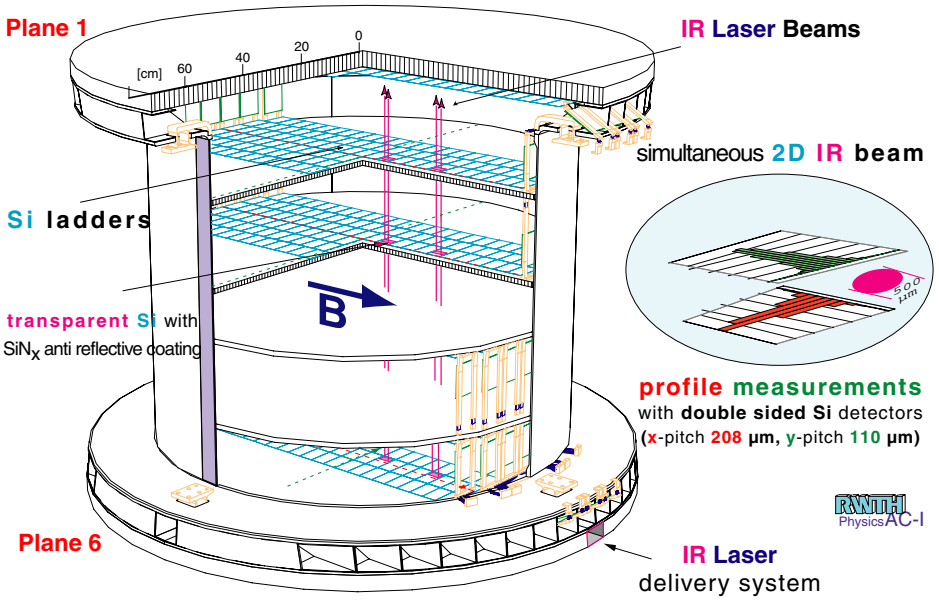


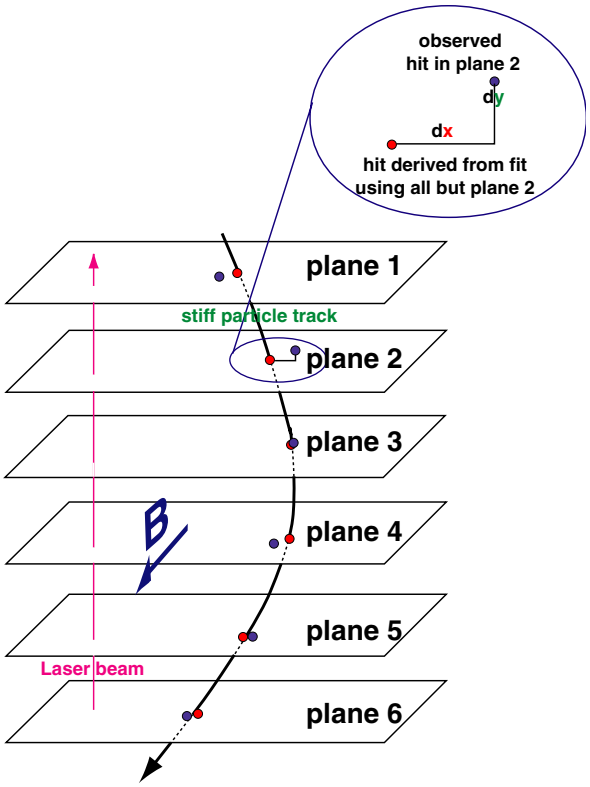
Beam-Test Result (120 GeV μ)



Residual distribution of hits on the ladder with respect to the position expected from the beam telescope.

AMS-02 Laser Alignment

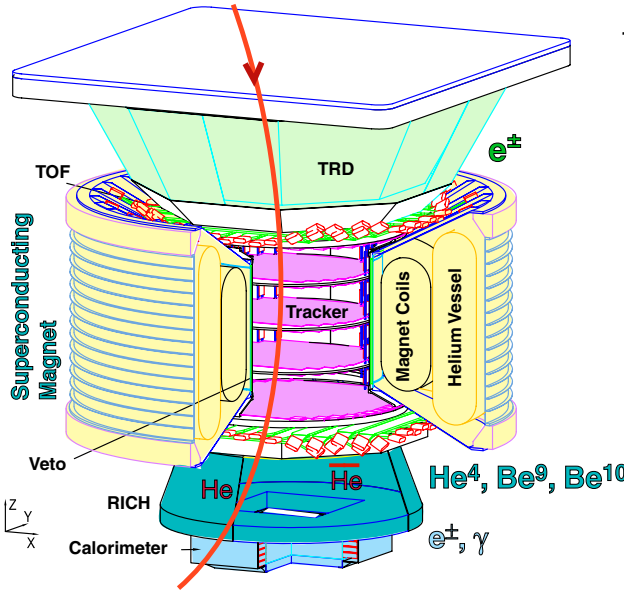


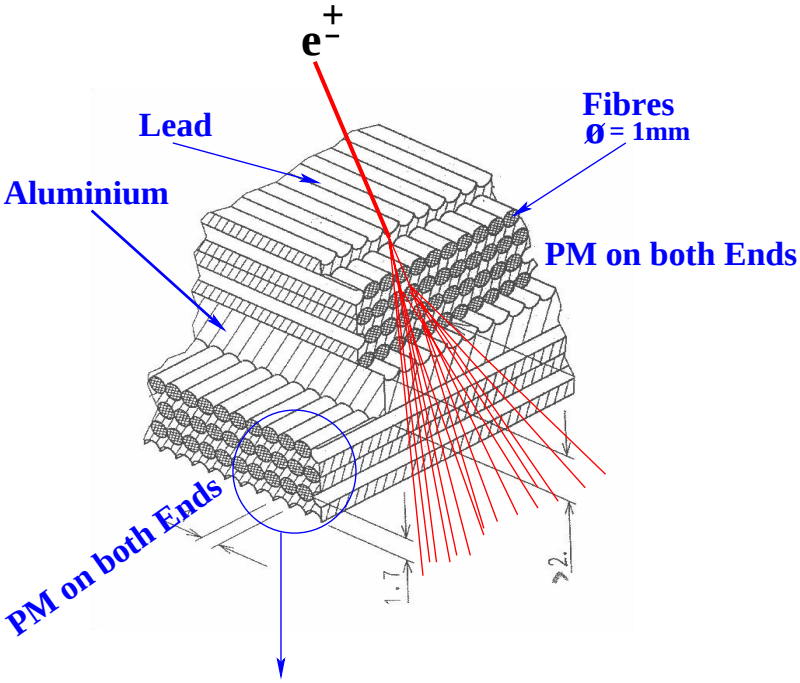


AMS-02 ECAL

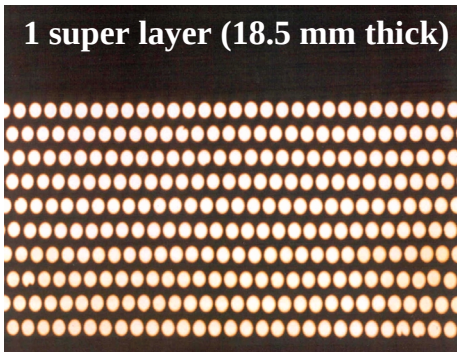
3D Sampling, 15 X_0 of Pb + scintillating fibres

Shower $\Rightarrow$ $e^{\pm}$-energy





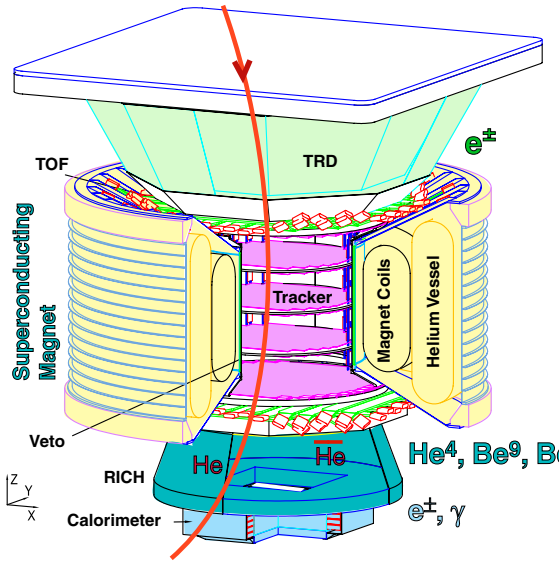
p^+-rejection $> 10^4$ (10 - 300 GeV)



Total: 9 super layers 15 X_0:

$$\frac{\sigma}{E} = \frac{12\%}{\sqrt{E}} + 1.5\% \qquad \text{(E in GeV)}$$

AMS-02 TRD



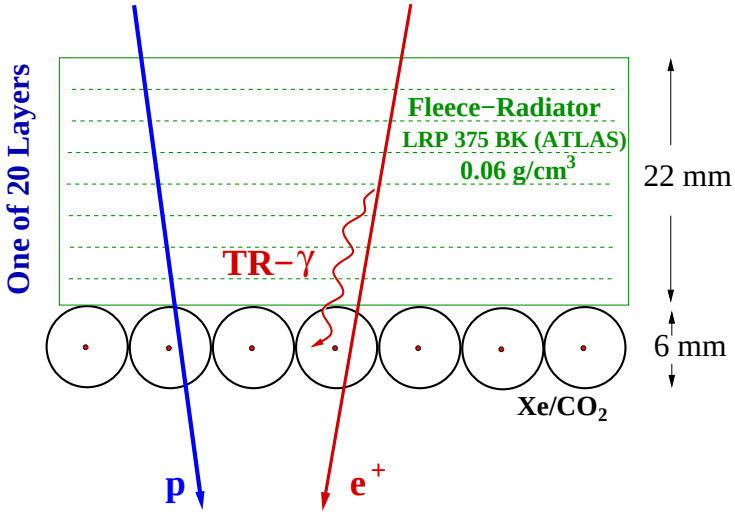
p^+-rejection $> 10^2$ (10 - 300 GeV)

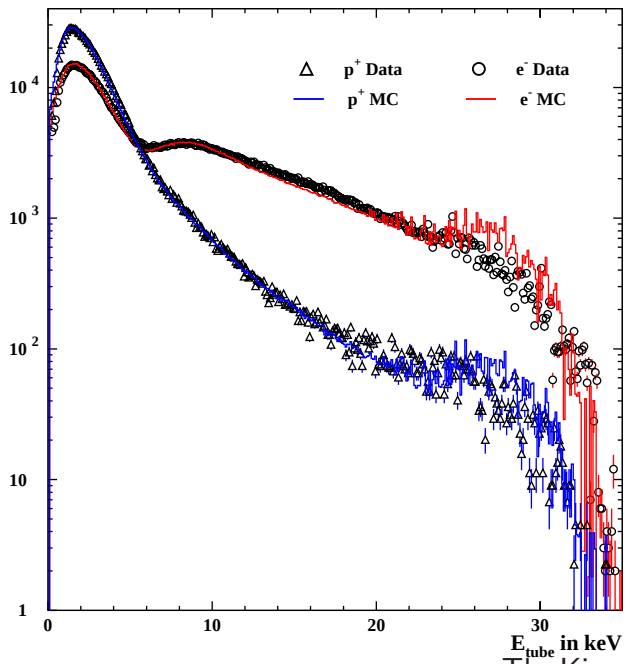
Chosen Configuration for 60 cm height:

20 Layers each existing of

- 22 mm fleece
- ∅ 6 mm straw tubes (Xe/CO_2 (80/20))

Realisation: HERAb/ATLAS

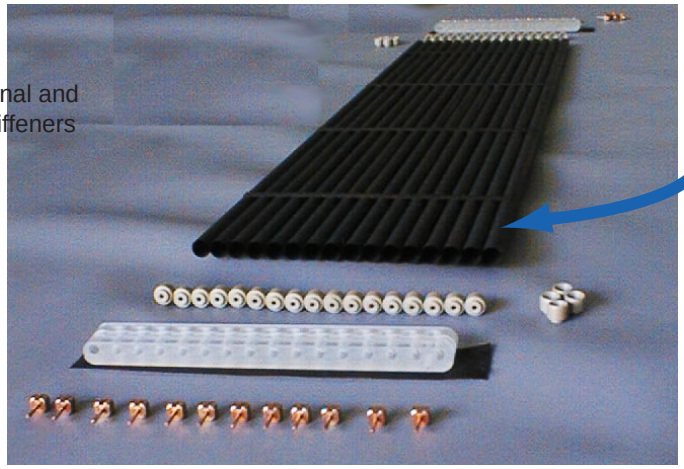


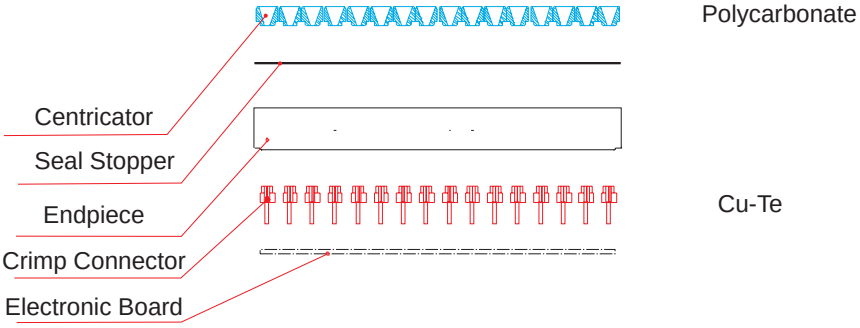


Straw Modules

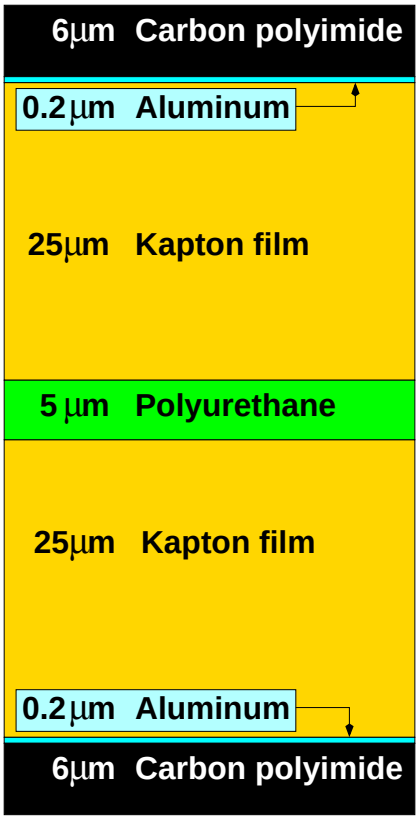
Module: 16 tubes at 6mm ∅ with 30 μm W-Au wire

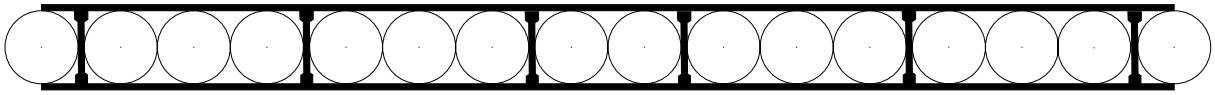
Multilayer Capton tubings





Capton wall





6 longitudinal stiffeners

Strips across every 10 cm

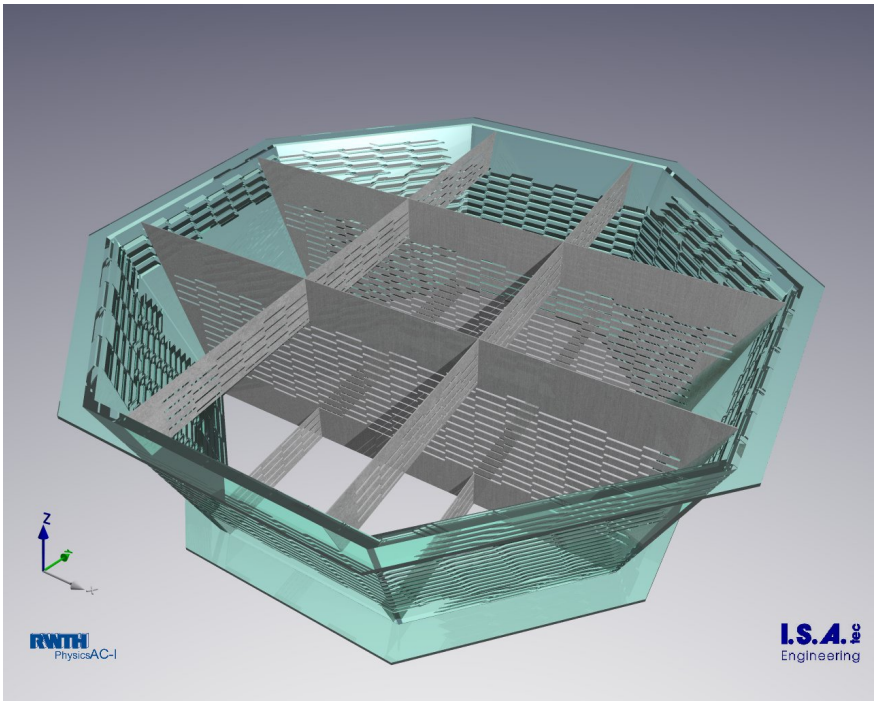
Vortrag:

Entwicklung und Bau des AMS-Übergangsstrahlungsdetektors

St. Fopp, T407.4, Do 14:45, HS7

AMS-02 TRD

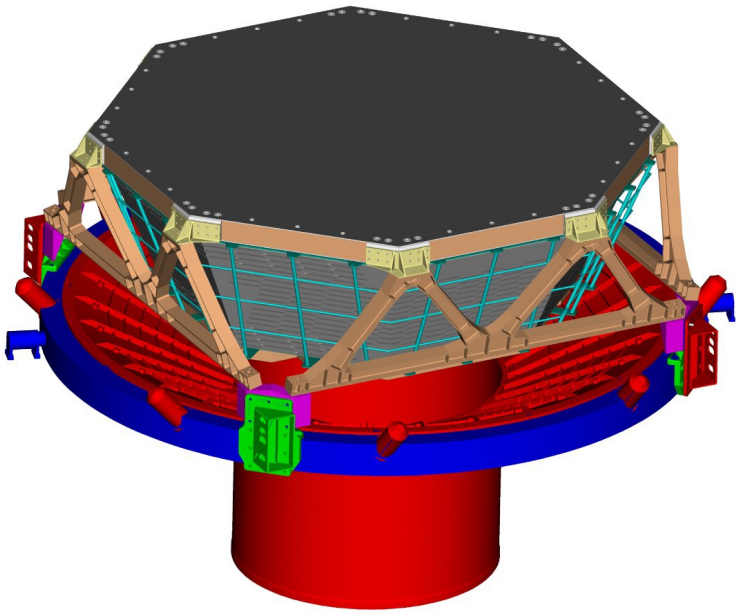
Octagon and Bulkheads support 328 Modules
(L=86 to 201 cm) with 100 μm mech. accuracy



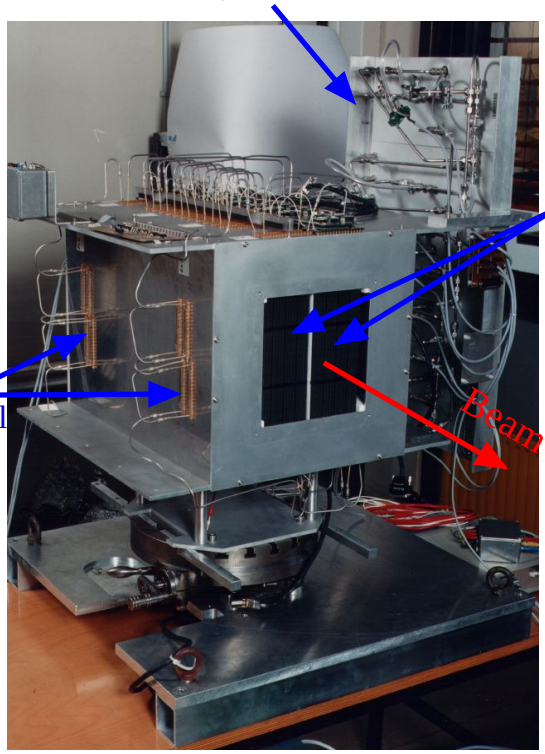
Upper/lower 4 layers
measure in bending plane

Middle 12 layers
measure in perpendicular plane

Vortrag: Test des AMS TRD mit Myonen aus der Höhenstrahlung
F. Dömmecke, T407.3, Do 14:30, HS7



AMS-02 TRD

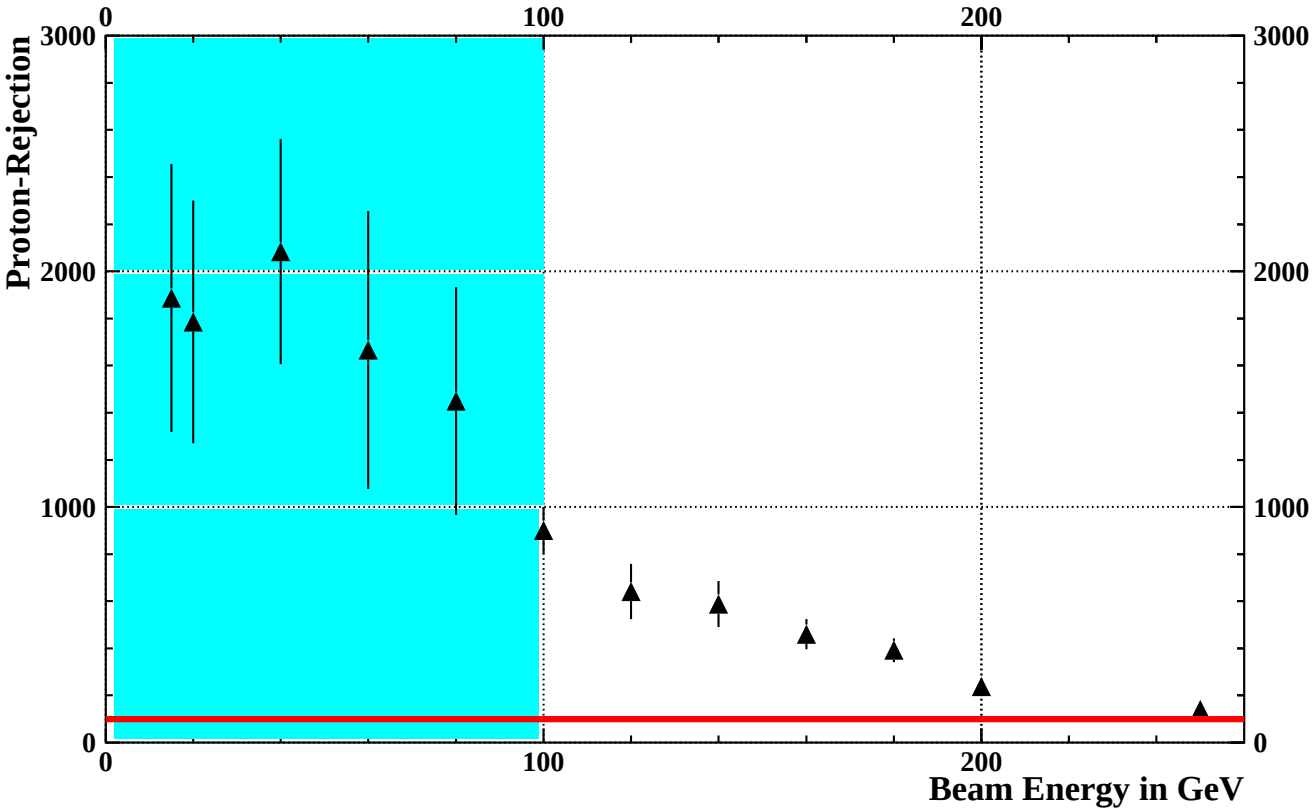


20 Layer Prototype

Vortrag:

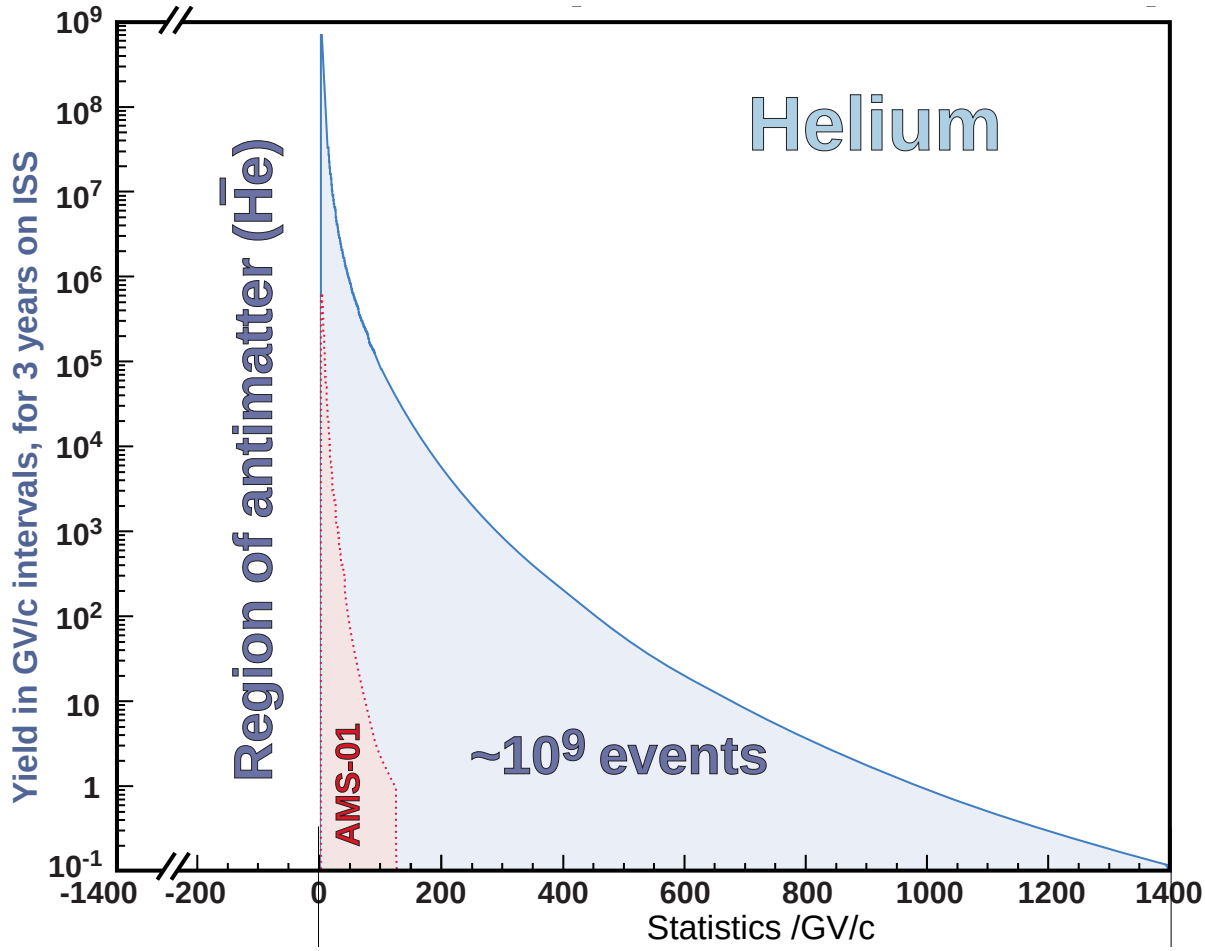
Strahltestergebnisse für den AMS-Übergangsstrahlungs-detektor

J. Orboeck, T407.5, Do 15:00, HS7



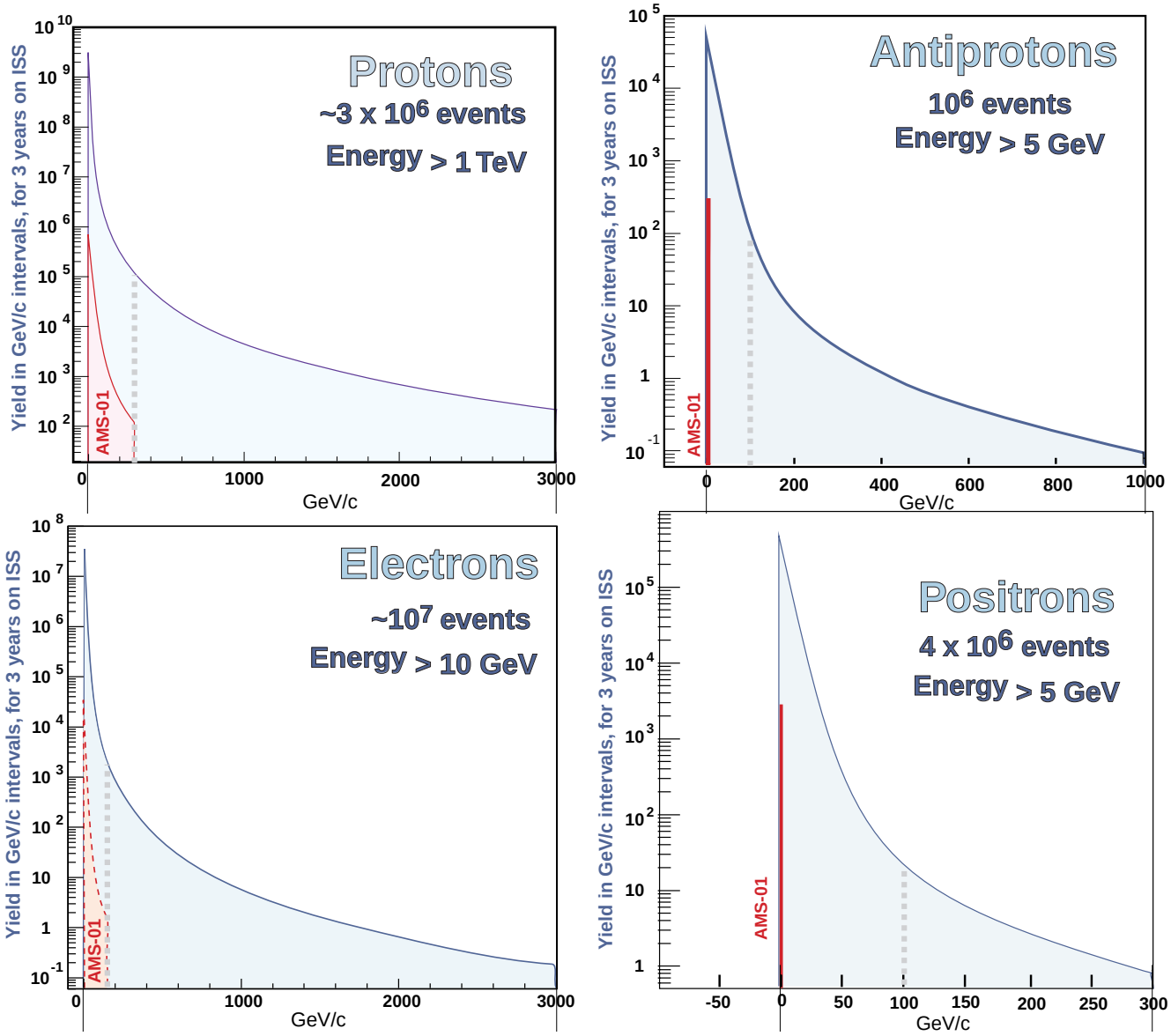
AMS02 Expectations

AMS01 statistics $\times 10^3$ momentum reach $\times 6$



$1 \cdot 10^9$ He 1 - 1400 GV

AMS02 Expectations



Conclusion + Outlook

- AMS-02 will have the unique possibility to measure in space, with the same detector

  γ, p, e^+- spectra + nuclei isotopes

- AMS-02 offers a world wide unique discovery potential for new physics
- Operation of a modern particle physics detector in space for 3 years is a technical challenge.
- AMS02 Assembly end of 2003
- Set for liftoff in Nov. 2004